

NEW RECORDS OF THE CESTODE GENUS *PSEUDOTOBOTHRIUM* (TRYPANORHYNCHA; OTOBOTHRIIDAE) FROM AUSTRALIAN FISHES

by I. BEVERIDGE¹, R. A. CAMPBELL,² & M. K. JONES³

Summary

BEVERIDGE, I., CAMPBELL, R. A. & JONES, M. K. (2000) New records of the cestode genus *Pseudotobothrium* (Trypanorhyncha; Otobothriidae) from Australian fishes. *Trans. R. Soc. S. Aust.* 124(2), 151–162. 30 November, 2000.

Pseudotobothrium dipsacum (Linton, 1897) is reported from the Australian region for the first time from various species of teleost fishes and is redescribed and compared with specimens from other parts of the world. *Pseudotobothrium arii* (Bilgees & Shaukat, 1976) comb. nov. is redescribed based on specimens from the catfish *Arius graeffii* Kner & Steindachner, 1866 from Queensland and is assigned provisionally to the genus *Pseudotobothrium*. The relationships of *Pseudotobothrium* with other otobothriid genera are discussed. The analysis of anatomical features presented indicates the validity of the genus *Pseudotobothrium* and that it possesses an atypical heteroacanthous armature consistent with its position within the family Otobothriidae Dollfus, 1942. The family Pseudotobothriidae Palm, 1995 is therefore considered a synonym of Otobothriidae Dollfus, 1942.

KEY WORDS: Cestodes, fishes, new host records, *Pseudotobothrium*, *Otobothrium dipsacum*, *Otobothrium arii*, Otobothriidae.

Introduction

Cestodes (tapeworms) of the order Trypanorhyncha Diesing, 1863 occurring in Australian fishes are still relatively poorly known since large numbers of potential host species as well as geographic regions around the continent remain to be examined. Amongst the most poorly investigated families of this cestode order is the Otobothriidae Dollfus, 1942, currently represented in this region only by *Otobothrium mugilis* Hiscock, 1954 (Hiscock 1954) and *Poecilancistrum euryphyllum* (Diesing, 1850) (Beveridge & Campbell 1996).

In the present paper, the occurrence of the genus *Pseudotobothrium* Dollfus, 1942, based on its only known species, *P. dipsacum* (Linton, 1897), is reported for the first time in fishes from northern Australia. *Otobothrium arii* Bilgees & Shaukat, 1976 is also reported from teleost fishes from Queensland and is placed within the genus *Pseudotobothrium*. Because the definition of the genus and descriptions of both species included in this report are incomplete (Beveridge *et al.* 1999), redescriptions based on Australian specimens as well as other specimens available for examination in museum collections are

provided. In addition, the taxonomic relationships of *Pseudotobothrium* within the family Otobothriidae are reassessed.

Materials and Methods

Cestodes collected by the authors were placed in tap water to induce evagination of the tentacles and were then fixed with 10% formaldehyde or 70% ethanol. Specimens were subsequently stained with Celestine blue, dehydrated in an ethanol series, cleared in methyl salicylate and mounted in Canada balsam. Tentacles were detached from strobila using a scalpel and were then mounted in glycerine jelly for examination of the tentacular armature. Drawings were made using a BH-2 Olympus microscope with Nomarski interference optics, fitted with a drawing tube. Measurements are presented in micrometres unless otherwise stated as the range followed by the mean and number of specimens measured in parentheses.

Specimens in the collections of the South Australian Museum, Adelaide (SAM), the Queensland Museum, Brisbane (QM), the British Museum (Natural History), London (BMNH), the Muséum national d'Histoire naturelle, Paris (MNHN) and the United States National Parasite Collection, Washington (USNPC) were examined.

A complete synonymy for *P. dipsacum* was provided by Dollfus (1942). Consequently, the references cited here are those in which novel host or geographic records are listed including those cited by

¹Department of Veterinary Science, The University of Melbourne Parkville, Vic. 3052.

²Department of Biology, University of Massachusetts Dartmouth, North Dartmouth 02743 USA.

³Centre for Microscopy & Microanalysis, The University of Queensland St Lucia Qld 4072.

Bates (1990). Records such as those of Linton (1913), Pintner (1934), Joyeux & Baer (1936) and Southwell (1913, 1930) which merely repeat previously published accounts have been excluded.

Host nomenclature follows Paxton *et al.* (1989), Robins *et al.* (1991) and Allen (1997).

Pseudotobothrium Dollfus, 1942

Type species : *P. dipsacum* (Linton, 1897)

Pseudotobothrium dipsacum (Linton, 1897)

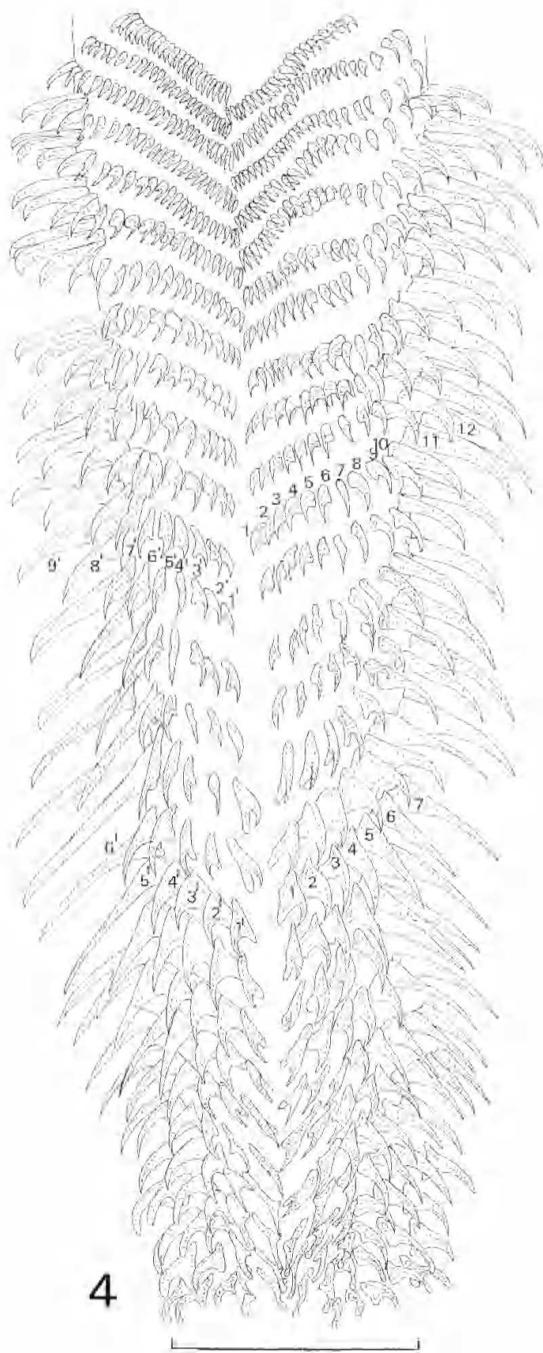
(FIGS 1-9)

Otobothrium dipsacum Linton, 1897, pp. 806-807, pl. 64, figs 1-5 (*Pomatomus saltatrix* (Linnaeus, 1766), Atlantic, North America, Massachusetts); Linton, 1901, pp. 412, 451 (*Pomatomus saltatrix*); Linton, 1905, pp. 329, 331, 375 (*Centropristes striata* (Linnaeus, 1758), Atlantic, North America,



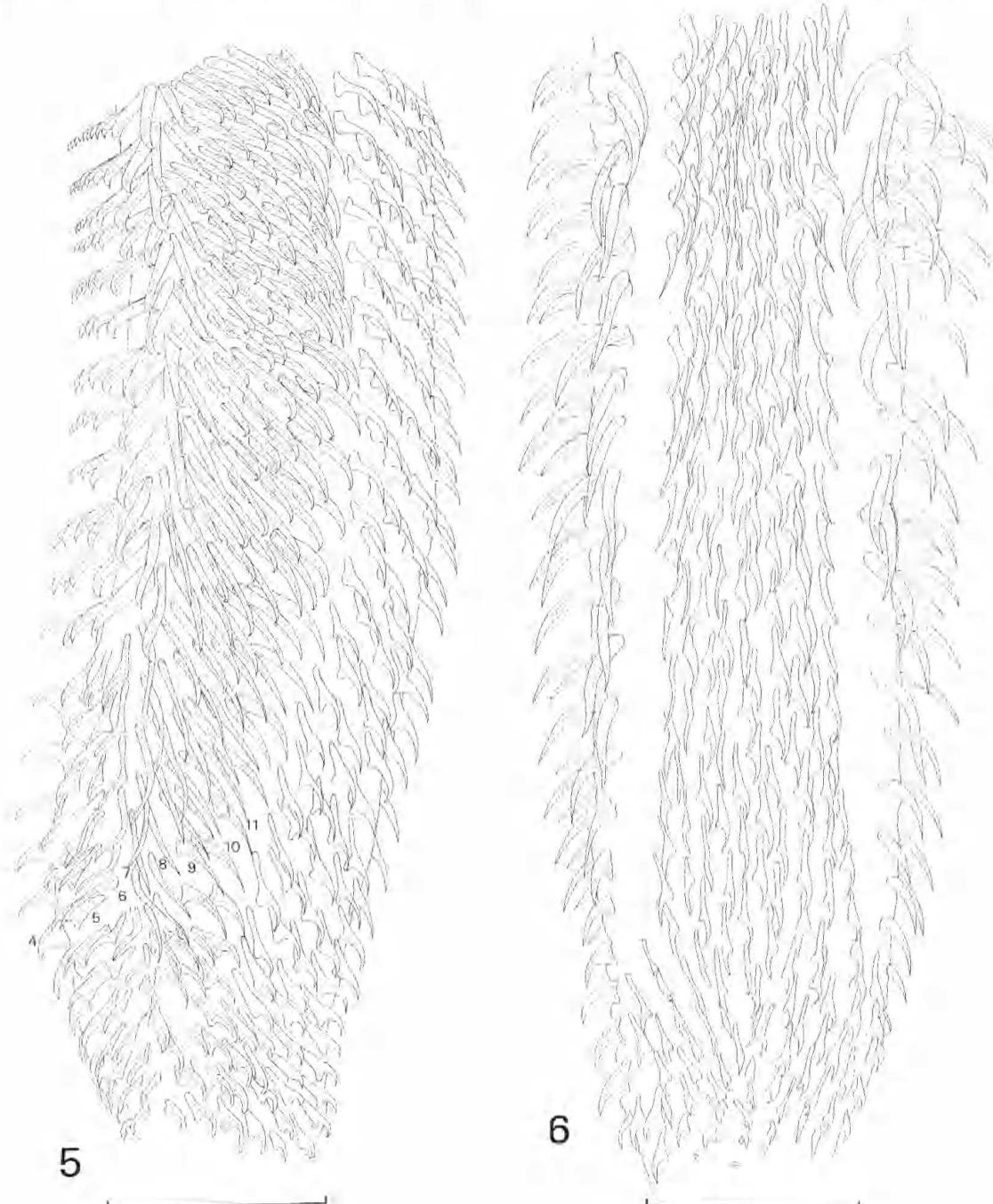
Figs 1-3. *Pseudotobothrium dipsacum* (Linton, 1897). 1. Scolex, 2. Bothridial pit, lateral view. 3. Tentacular bulb, showing origin of retractor muscle. Scale bars = 0.1 mm.

North Carolina); Southwell, 1912, pp. 270, 278, figs 19-21 (identified as *O. insigne*) (*Epinephelus undulosus* (Quoy & Gaimard, 1824) (=*Serranus undulosus*), *Parastromateus niger* (Bloch, 1795) (=*Stomateus niger*), *Diagramma crassispinum* Rüppell, 1838, *Ballistes* spp., Sri Lanka (illustrations are not of *O. dipsacum*); Linton, 1924, p. 2, 53



(*Aluterus schoepfi* (Walbaum, 1792) (=*Ceratacanthus schoepfi*). *Xiphias gladius* (Linnaeus, 1758), Atlantic, North America,

Massachusetts; *Trachinotus falcatus* (Linnaeus, 1758) (=*Mycteroperca falcata*), Atlantic, North America, Florida); Southwell, 1924, p. 489



Figs 4-6. *Pseudobothrium dipsacum* (Linton, 1897), basal and metabasal tentacular armature. 4. Antibothridial surface of tentacle showing origins of ascending hook rows with slight space between files 1 and 1' in metabasal region. 5. External surface of tentacle showing ascending rows of hooks from left to right and band of hooklets on bothridial (right) side of tentacle. 6. Bothridial surface of tentacle showing band of hooklets in centre with prominent space on either side of the band. Scale bars = 0.01 mm.

(*Epinephelus undulosus*, *Diagramma crassispinum*, Sri Lanka); Southwell, 1929, pp. 291-292, 311, fig. 47 (*Epinephelus undulosus*, *Diagramma crassispinum*, *Sufflamen fraenatus* (Latreille, 1804) (=*Balistes mitis*), *Linjanus dodecavanthus* (Bleeker, 1853), *Lethrinus ornatus* Valenciennes, 1830, Sri Lanka, p. 311, *Abalistes stellatus* (Lacépède, 1798) (=*Balistes stellatus*), *Lethrinus ornatus*, *Parastromateus niger*); Yamaguti, 1952, pp. 69-70, fig. 105 (*Chelidonichthys kuhni* (Cuvier, 1829), Japan); Palm et al., 1994, pp. 153, 156, 159, fig. 4 (*Cynoglossus senegalensis* (Kaup, 1858), *Petrocephalus bane* (Lacépède, 1803), Gulf of Guinea).

Otobothrium (*Pseudotobothrium*) *dipsacum*: Dollfus, 1942, pp. 253-255, fig. 157 (*Poly nemus quadrifilis* Cuvier & Valenciennes, 1829) East

Atlantic, Africa (Congo)(identification uncertain); Cruz-Reyes, 1973, 25-29, figs 1-5 (*Balistes polylepis* Steindachner, 1876, Pacific Ocean, Mexico).

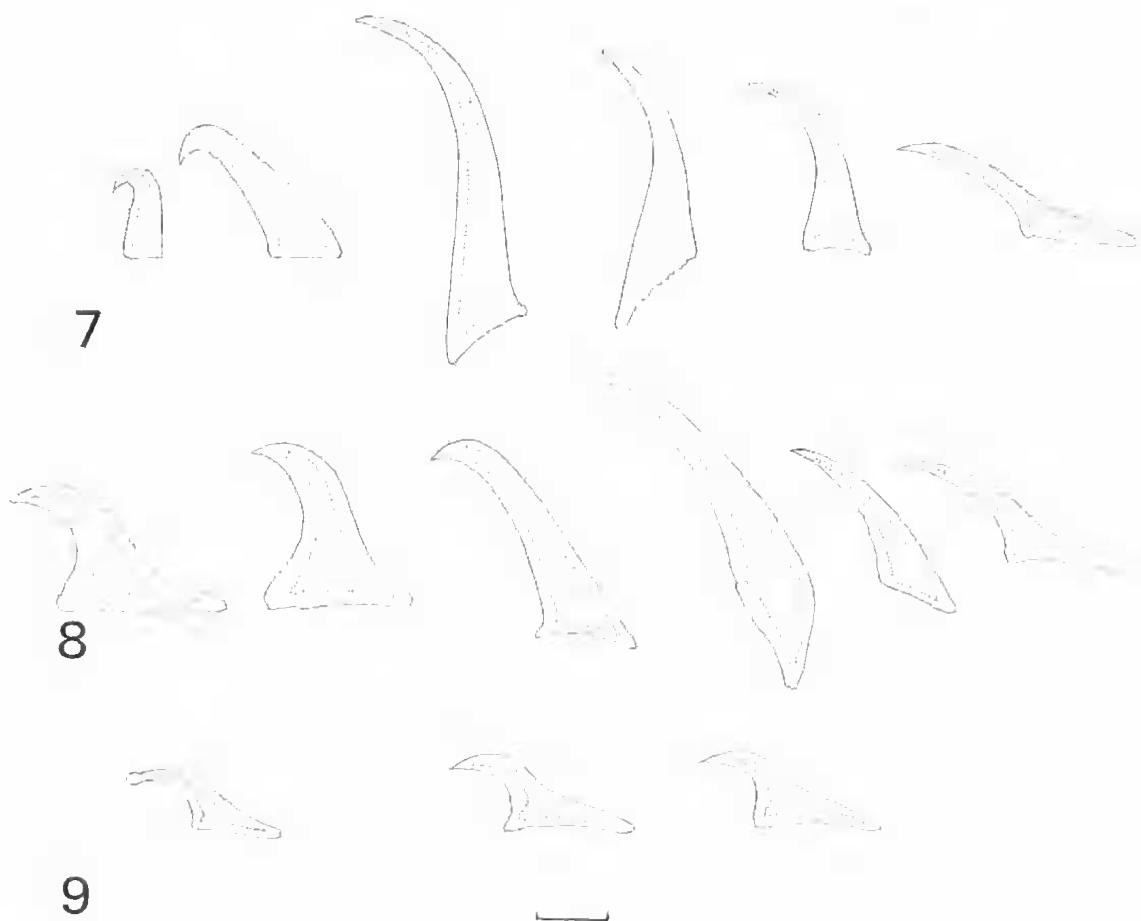
Pseudotobothrium dipsacum: Ward, 1954, p. 255, fig. 8 (*Sphyraena barracuda* (Walbaum, 1792), Miami, USA); Palm, 1995, pp. 102-103, 154-162 (*Haemulon plumieri* (Lacépède, 1801), Brazil); Palm et al., 1997b, pp. 71, 72, 75 (*Pseudupeneus maculatus* (Bloch, 1793), *Haemulon plumieri*, Atlantic, Brazil), 1997b, p. 84, figs 1c, 1d.

Types: Holotype (larval) from *Pomatomus saltatrix* (Linnaeus, 1766) (USNPC 4794).

Material examined:

From Australia:

from *Abalistes stellatus* (Lacépède, 1798): 5



Figs 7-9. Profiles of hooks from the tentacular armature of *Pseudotobothrium dipsacum* (Linton, 1897). 7. Metabasal region, from left, first hook in row, hook in middle of row, hook near end of row, terminal hook of row, outer hooklet from band, inner hooklet from band. 8. Hooks of rows 10-15 from the base, from left, first hook of row 10, first hook of row 15, hook in middle of row 15, hook at end of row 15, outer hooklet of band, inner hooklet of band. 9. Hooks from base of tentacle, from left, lobed hook on antibothridial surface, outer hook of band, inner hook of band. Scale bar = 0.01 mm.

- specimens, Heron Island, Qld (QM G217928-32); from *Cephalopholis cyanostigma* (Kuhl & van Hasselt, 1828); 1 specimen, Heron Island, Qld (QM G214959); from *Epinephelus suillus* (Valenciennes, 1828); 7 specimens, Cape Cleveland, Qld (SAMA 31342); from *Istiophorus platypterus* (Shaw & Nodder, 1792); 4 specimens, Cape Bowling Green, Qld (QM G212165, 212799); from *Makaira indica* (Cuvier, 1832); 2 specimens, Cape Bowling Green, Qld (QM G212166, 212800); from *Makaira mazara* (Jordan & Snyder, 1901); 2 specimens, Cape Moreton, Qld (QM G212785, 212798); from *Naso flaminius* (Valenciennes, 1835); 1 specimen, Heron Island, Qld (QM G212960); from *Pseudocurimx dentex* (Bloch & Schneider, 1801); 2 specimens, Heron Island, Qld (QM G214961, 217936); from *Plectropomus leopardus* (Lacépède, 1802); 2 specimens, Heron Island, Qld (QM G214962); from *Plectropomus maculatus* (Bloch, 1790); 1 specimen, Heron Island, Qld (QM G206964); from *Rhinecanthus rectangulatus* (Bloch & Schneider, 1801); 3 specimens, Heron Island, Qld (QM G217933-5); from *Gymnosurus unicolor* (Rüppell, 1836); 2 specimens, Clerke Reef, WA (SAMA 31343). From Indian Ocean: from *Lutjanus gibbus* (Forsskål, 1775); 1 specimen, Hulule, Maldives (QM GL 10508). From East Africa: from *Cephalopholis sonneratii* (Valenciennes, 1828); 1 specimen, Zanzibar (BMNH 1961.6.26.120-5); from *Epinephelus malabaricus* (Bloch & Schneider, 1801); 5 specimens, Zanzibar (BMNH 1961.6.26.120-5); from *Epinephelus tanyina* Forsskål, 1775; 3 specimens, Zanzibar (BMNH 1961.6.26.120-5); from *Epinephelus chlorostigma* (Valenciennes, 1828); 4 specimens, Persian Gulf (BMNH 1992.7.13.1-15). From Sri Lanka (Ceylon): from *Sufflamen fraenatus* (Latreille, 1804) (=*Balistes mitis*); 1 specimen (BMNH 1997.11.15.33-7); from *Abalistes stellatus* (Lacépède, 1798); 6 specimens (BMNH 1977.11.15.33-7); from *Lethrinus ornatus* Valencienne, 1830; 2 specimens (BMNH 1977.11.15.31-2); from *Lethrinus* sp.; 1 specimen (BMNH 1977.11.15.58-62); from *Epinephelus undulatus* (Quoy & Gaimard, 1824) (=*Serranus undulatus*); 5 specimens (USNPC 49816). From South America: from *Haemulon plumieri* (Lacépède, 1801); 1

specimen, Brazil (in personal collection of H. Palm).

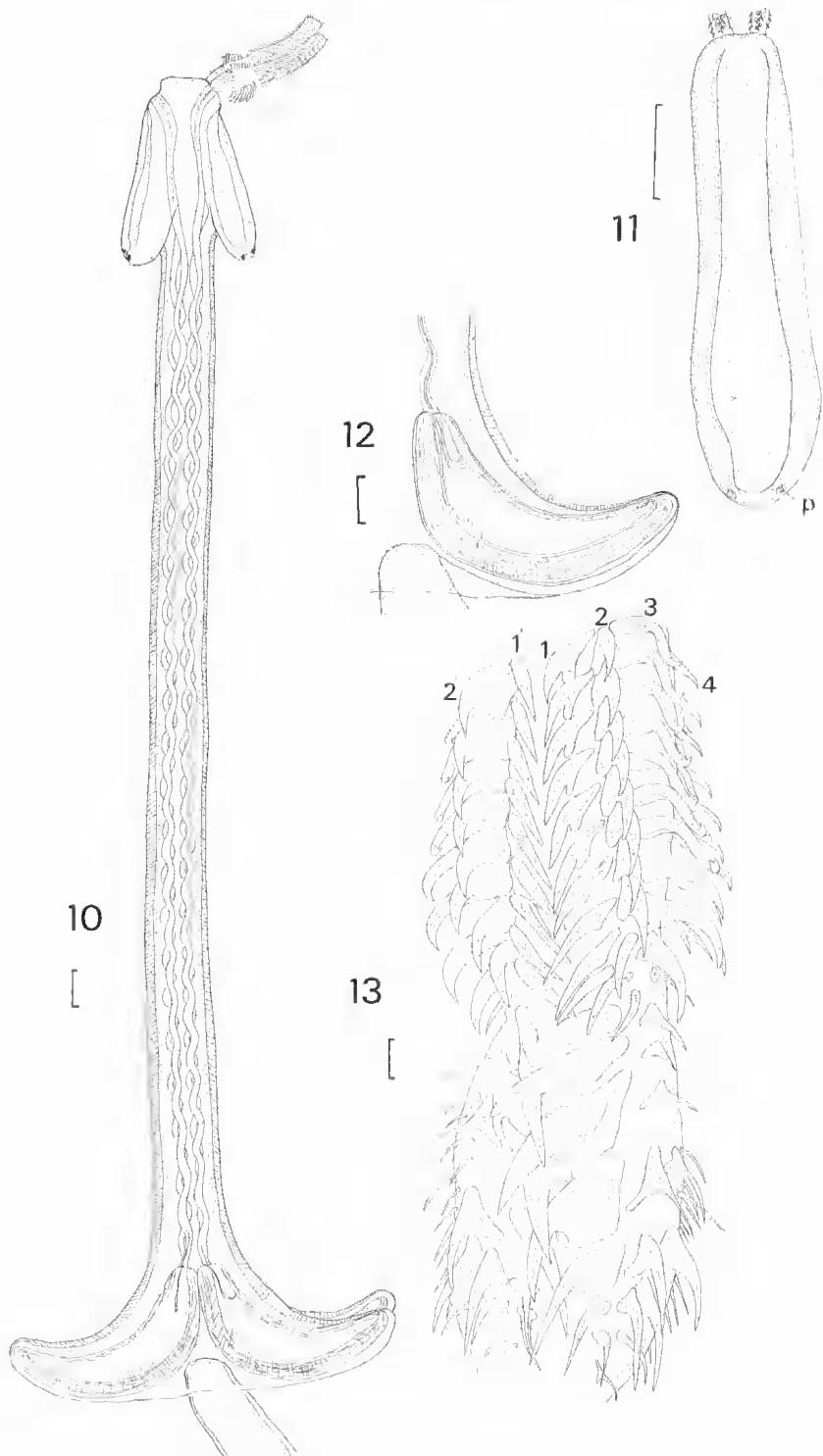
From North America:

- from *Pomatomus saltatrix* (Linnaeus, 1766); type; from *Mycteroperca phenax* Jordan & Swain, 1884; 8 specimens, New York Aquarium (USNPC 35777); from *Haemulon parra* (Desmarest, 1823) (= *Neomaenius parra*); 2 specimens, New York Aquarium (USNPC 35780, 35781); from *Canthidermis sufflamen* (Mitchill, 1815); 2 specimens (USNPC 35782); from *Canthidermis maculatus* (Bloch, 1786); 1 specimen, New York Aquarium (USNPC 35852); from *Ocyurus chrysurus* (Bloch, 1791); 1 specimen, New York Aquarium (USNPC 35783); from *Harpie rufa* Linnaeus, 1758; 1 specimen, New York Aquarium (USNPC 35850); from *Scorpaena plumieri* Bloch, 1789; 1 specimen (USNPC 35851); from *Dicope analis* Cuvier & Valenciennes, 1830 (= *Neomaenius analis*); 1 specimen, New York Aquarium (USNPC 35853); from *Larimolaimus maximus* (Wahlbaum, 1792); 1 specimen, New York Aquarium (USNPC 36028).

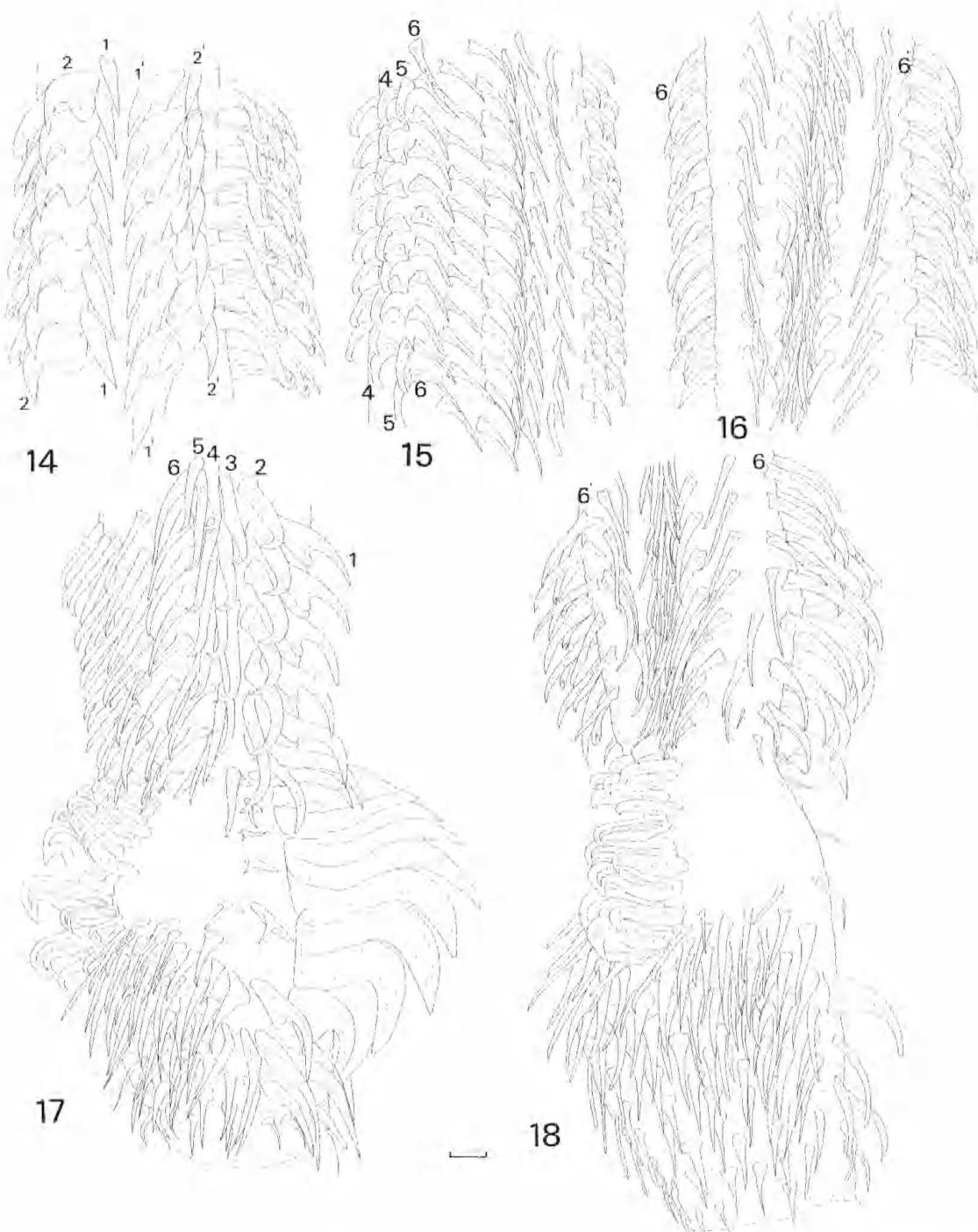
Description

Measurements from Australian specimens. Scolex 3.3-5.0 (4.2, n=10) mm long; maximum width at posterior extremity 0.83-1.42 (1.12, n=10) mm; pars bothridialis 1.05-1.40 (1.28, n=10) mm, 2 bothridia with thick margins, posterior margin of each bothridium with 2 prominent fossettes; pars vaginalis variable in length, depending upon state of contraction of specimen, 1.88-3.40 (2.58, n=10) mm, prominent longitudinal muscles between tentacular sheaths; bulbs elongate, 1.19-1.70 (1.42, n=10) mm long, 0.20-0.30 (0.25, n=10) mm wide, length:width ratio 4.10-7.35 (5.92, n=10), posterior extremities of bulbs directed laterally, terminating at postero-lateral margin of velum; prebulbar organ absent; retractor muscle originating from anterior half of internal wall of bulb; no gland cells present within bulbs; scolex ratio (pho:pvag:phlb = 1:1.23:1.10); scolex eraspedote, length of velum 0.26-0.50 (0.39, n=10) mm long, pygidium 0.40-0.65 (0.54, n=10) mm long.

Tentacles of relatively uniform diameter for most of length, without basal swelling, slightly narrower at base, 80-150 (120, n=10) in diameter at base, 100-160 (140, n=10) in diameter in metabasal region; 1450-2200 (1940, n=10) long when fully extended, tapering at tip, with approx. 125 rows of hooks. Armature heteroacanthous, heteromorphic; hooks hollow; no distinct basal armature. Hooks arranged in ascending half-rows, rows beginning on antibothridial surface, terminating on bothridial surface; slight space between hook files I and II on antibothridial surface, most prominent between rows 6 and 20; number of hooks changes along tentacle: 10 rows from base, 10



Figs 10-13. *Pseudotothothrium arii* (Bilqees & Shaukat, 1976) comb. nov. 10. Scolex showing lateral extension of posterior region of pars bulbosa. 11. Bothridium showing bothridial pits (p) at posterior extremity of bothridium. 12. Tentacular bulb, showing origin of retractor muscle. 13. Basal and metabasal armature, bothridial surface, showing interlocking files of hooks at base and origins of ascending hook rows of metabasal region. Scale bars = 10-12, 0.1 mm; 13, 0.01 mm.



Figs 14-18. *Pseudotobothrium arii* (Bilqees & Shaukat, 1976) comb. nov. Tentacular armature. 14. Metabasal region, bothridial surface, showing origins of hook rows. 15. Metabasal region, external surface, showing ascending rows of hooks on left and band of hooklets on right. 16. Metabasal region, antithoracal surface, showing central band of hooklets with flanking file of hooklets on each side. 17. Basal region, external surface, bothridial aspect with interlocking large hooks on right hand side, bill-hooks on antithoracal surface on left hand side. 18. Basal region, oblique view of antithoracal surface showing bill-hooks on antithoracal surface of base and origin of band of hooklets in metabasal region. Scale bar = 0.01 mm.

hooks per principal row; 20 rows from base, 15 hooks per row; 25 rows from base, 40 hooks per row; increase in number of hooks occurs at origins of rows on anterobothridial surface; number of hooks per row diminishes towards tip of tentacle; 110 rows from base, 30 hooks per row, 120 rows from base, 20 hooks per row. Hooks change slightly in shape along tentacle. At base, hooks on anterobothridial surface uncinate, blade tips bulbous, bases broad, hooks 20-33 (28, n=10) long, base 12-20 (18, n=10); on bothridial surface of tentacle hook tips sharp, bases elongate; from rows 5 to 10, hooks 1(1') small, uncinate, 21-33 (26, n=10) long, base 21-25 (23, n=10), blade becoming much longer than base along row, largest hooks of rows elongate, falcate to triangular, 50-62 (56, n=10) long, base 13-20 (17, n=10); from rows 10-15, hooks 1(1') diminish in size, remain uncinate; hooks 7(7'), 8(8') elongate, falcate to spiniform; from row 20 distally, hooks 1(1') to 20 (20') small, uncinate, with narrow base and sharply rebated hook tip, 13-19 (15, n=10) long, base 6-9 (7, n=10), closely packed; hooks on internal and external surfaces elongate, spiniform, longest hooks of each row 52-67 (60, n=10) long, base 14-20 (18, n=10); final file of hooks of each principal row 35-50 (44, n=10) long, base 8-17 (13, n=10). On bothridial surface, distal to row 5, space present between final hook of principal row and central band of 10 files of smaller hooklets. At base of tentacle, all hooklets of band uncinate, with elongate base; in metabasal region, hooklets of outer files with short bases, 32-36 (35, n=10) long, base 8-11 (10, n=10); hooklets of inner files retain elongate bases, 26-44 (35, n=10) long, base 12-22 (16, n=10). Band of hooklets with 1 row of hooklets for each principal hook row; arrangement of band of hooklets not perfectly regular. Adult unknown.

Pseudotothorium urii
(Bilqees & Shaukat, 1976) comb. nov.
(FIGS 10-18)

Otothorium urii Bilqees & Shaukat, 1976, pp. 119-124, fig. 1 (*Arius serratus* Duy. 1877, Karachi).
Types: School of Parasitology, Department of Zoology, University of Karachi (not examined).

Material examined:

From *Arius serratus* Duy. 1877: Pakistan ± 1 specimen, Karachi, ident. by Dr F. M. Bilqees, BMNH 1989.5.18.14.

From *Arius greeffii* Kner & Steindachner, 1866: Australia: 3 specimens, Brisbane, Queensland, coll. M. K. Jones, Rix, 1997 (SAMA 28271), 23.x.1997 (SAMA 28266).

Description

Measurements from Australian specimens. Scolex

3.1, 3.5, 4.1 mm long, maximum width in pars vaginalis 0.15, 0.16, 0.22 mm, at posterior extremity 0.94, 1.10, 1.23 mm; pars bothridialis 0.45, 0.49, 0.55 mm, 2 bothridia with distinct margins, posterior margin of each bothridium with 2 small but prominent fossettes; pars vaginalis variable in length, depending upon state of contraction of specimen, 2.74, 3.11, 3.50 mm; bulbs elongate, 0.50-0.70 (0.57, n=5) mm long, 0.15-0.22 (0.18, n=5) mm wide, length:width ratio 2.73-3.68 (3.26, n=5), bulbs directed almost laterally, terminating at postero-lateral margin of velum; prebulbar organ absent, retractor muscle originating in anterior extremity of internal wall of bulb; no gland cells present within bulbs; scolex craspedote, length of velum 0.15 mm; scolex ratio (pbo:pvag:phbulb) = 1:6.24:1.14.

Tentacles with distinct basal swelling, 50, 60 in diameter at base, 40, 40 in diameter in metabasal region. Armature heteroacanthous, heteromorphous, hooks hollow; distinct basal armature. Basal armature with hooks 1(1') on bothridial surface greatly enlarged, bases close together such that blades interdigitate, 40-70 (57, n=10) long, base 20-30 (26, n=5). Hooks on posterior part of internal and external surfaces of basal swelling arranged in c. 10 rows; hooks spiniform with narrow bases, 19-27 (22, n=10) long, base 4-8 (6, n=10); anterior part of basal swelling on both internal and external surfaces devoid of hooks. External surface of basal swelling with row of bill-shaped hooks, 25-32 (28, n=10) long, base 5-8 (6, n=10). Metabasal armature; hooks arranged in ascending half-rows; rows begin on bothridial surface, terminate on anterobothridial surface; 6 hooks per principal row; very slight space between hook files 1 and 1' on bothridial surface, diminishing in width posteriorly and disappearing at level of base. Hooks 1(1') large, uncinate, 28-32 (30, n=5) long, base 18-26 (21, n=5). Hooks 2(2') uncinate, smaller, 19-30 (25, n=10) long, base 14-20 (17, n=10); hooks 3(3') erect, uncinate with sharply recurved tips and narrow bases, 17-32 (22, n=10) long, base 5-8 (7, n=10); hooks 4(4') to 6(6') spiniform with very narrow bases and recurved tips, 20-31 (25, n=10) long, base 4-10 (6, n=10). On anterobothridial surface, space present between final hook of principal row (6(6')) and central band of hooklets. Outer file of hooklets spiniform, 17-30 (23, n=10) long, base 4-6 (5, n=10), separated from central band of 4 files of spiniform hooklets 18-30 (23, n=10) long, base 4-6 (5, n=10); single row of hooklets per principal row. Adult unknown.

Discussion

Pseudotothorium dipsacum has been described by several authors. Linton (1897) gave a brief description of the species but did not describe the

armature in detail, apart from noting the closely spaced rows of hooks and the increase in number of hooks per row along the tentacle. The redescription provided by Cruz-Reyes (1973) was more detailed but the description of the armature was limited to one surface of the tentacle, that on which the hook rows commence.

Palm *et al.* (1994) provided scanning electron micrographs of the armature, while Palm (1995) provided a brief summary of the morphological features of *P. dipsacum* and a re-interpretation of its armature. He (1995, 1997a) proposed that the armature was of the typical heteroacanthous type with the hook rows beginning on the internal surface and terminating on the external surface of the tentacle, without extra rows of hooks on the latter surface. The armature had previously been considered to be of the atypical heteroacanthous type in which additional hooks are usually present on the external surface of the tentacle (Dollfus 1942). On the basis of this re-interpretation, Palm (1995) created a new family, Pseudotothriidae, for the species, although he cited it subsequently as "Pseudotothriidae Ward, 1954" (Palm 1997b, p. 75). The current re-description of the species provides morphological evidence which contradicts Palm's (1995, 1997a) hypotheses. Firstly, the hook rows in *P. dipsacum* begin on the antibothridial surface of the tentacle and end on the bothridial surface, a feature which has not been recorded previously in this species. In most trypanorhynchs, the principal rows begin on the internal surface and terminate on the external surface (Dollfus 1942; Campbell & Beveridge 1994). Exceptions to this pattern are the genera *Kotorella* Euzet & Radujkovic, 1989 and *Prochristinella* Dollfus, 1946, with rows beginning on the bothridial surface of the tentacle (Campbell & Beveridge 1994; Beveridge & Jones 2000). Palm *et al.* (1994) and Palm (1995, figs 155, 157) mistakenly identified the antibothridial surface as the external surface and the bothridial surface as the internal surface in descriptions of the armature. Palm subsequently (1997b, figs 1e, d) identified the bothridial surface as the external surface.

The second significant feature, noted here for the first time in this species, is the space between the principal rows of hooks and those occupying the centre of the bothridial surface of the tentacle. This space is clearly visible in various views of the tentacle but may be obscured when detached tentacles are manipulated in glycerine (Fig. 5), compressing some hooks against the surface of the tentacle. In addition to the spaces observed, there are significant differences in shape between the hooks at the ends of the principal rows and those in the centre of the bothridial surface of the tentacle (Figs 7, 8). For these reasons, the interpretation advanced here is

that the principal rows terminate as they approach the bothridial surface and that the hooklets on the bothridial surface form a "band", with each row in the band corresponding to a principal hook row. This interpretation conforms with the limited observations of Linton (1897) and Dollfus (1942) that there are no "extra" rows of hooks on the bothridial surface. The distinct "band" is a characteristic of the poecilacanthous trypanorhynchs in the system of Dollfus (1942) or the otobothrioids in the system of Campbell & Beveridge (1994) and is a feature of the related otobothrid genus *Poecilancistrum* Dollfus, 1929, in which there are three rows of hooklets for each principal row (Beveridge & Campbell 1996).

Consequently, *P. dipsacum* is an otobothrioid trypanorhynch on the basis of its armature and is allied with *Poecilancistrum* in the family Otobothriidae. An additional family, Pseudotothriidae, is not required and we therefore place Palm's (1995) family as a synonym of Otobothriidae.

There are, nonetheless, several unique features in the armature of *P. dipsacum*. The dramatic increase in numbers of hooks per principal row along the tentacle has been reported from no other trypanorhynch cestode. The number of hooks in the principal row is usually constant or diminishes distally along the length of the tentacle. In addition, it is unusual for the final or penultimate hook of the principal row to be the longest. Usually, the largest hook is at the commencement of or in the middle of the principal row. Thus there are adequate reasons for maintaining *P. dipsacum* as an independent species. Comparison of Australian specimens with material in museum collections suggests that *P. dipsacum* is a cosmopolitan species which is morphologically uniform throughout its geographic range. The material examined from Australia and other regions considerably expands the host range of the species.

Dollfus (1942) sub-divided the genus *Otobothrium* into two subgenera and erected the sub-genus *Pseudotothrium* (with type species *O. dipsacum*) primarily on the basis of armature. The sub-genus *Otobothrium* was characterised as having extra hooks or hook rows on the external surface of the tentacle, while in *Pseudotothrium*, the numbers of hook rows were the same on both surfaces of the tentacle. Dollfus (1942) also noted that in *Pseudotothrium* the bulbs were elongate, while in *Otobothrium* they were generally short. Yamaguti (1959) also subdivided *Otobothrium* into subgenera, basing the division primarily on the lengths of the bulbs and designating *O. linstowii* as the type species of the sub-genus *Pseudotothrium*, apparently overlooking the taxonomic decision of Dollfus (1942). Schmidt (1986) did not accept Yamaguti's

(1959) subdivision, while Campbell & Beveridge (1994) accepted the sub-genera but, following Yamaguti (1959), erroneously cited *O. linsnowi* as the type species of the sub-genus *Pseudobothrium*. Schmidt (1986) did not recognise the two sub-genera.

Cruz-Reyes (1973) redescribed *O. dipsacum* and considered *Otobothrium insigne* Linton, 1905 as its synonym for reasons which were not explained. Consequently, the host list for *P. dipsacum* given by Palm (1995), which follows Cruz-Reyes (1973), is a composite. As *O. insigne* is here regarded as a valid species based on the redescription by Hildreth & Lumsden (1985), the valid records of *O. dipsacum* are therefore those listed in the synonymy. Dollfus (1942) reported as possible specimens of *O. dipsacum*, pleurocerci collected from *Polypterus quadrifilis* and *Brachyalestes auritus* (Valenciennes, 1831) (=*Otopercula aurita*) from Pointe Padron, Congo (=Zaire). The illustrations of the specimens (Dollfus 1942, fig. 157) suggest that they belong to an undescribed species related to *O. insigne*, based on specimens from the same geographical region in Dollfus' collection (MNHN). There are no specimens of *P. dipsacum* in the Dollfus collection in MNHN and therefore Dollfus' (1942) records have not been included in the current list of hosts of *P. dipsacum*.

Bilgees & Sjaukat (1976) described *O. urii* based on pleurocerci from the musculature of a catfish, *Arius serratus* from Pakistan. They distinguished it from congeners primarily on the basis of number of files of hooks and the laterally divergent bulbs. They did not, however, give a detailed description of its armature. The three Australian specimens examined, also from a catfish, *Arius graeffii*, are identical to *O. urii* based on comparisons with a specimen in BMNH from the type host and locality, identified by Dr Bilgees. Both the scolex shape and the armature are highly distinctive. The pars vaginalis is extremely long and slender and the bulbs extend laterally, as in *O. penetrans* Linton, 1907, *O. pephrikos* Dollfus, 1969 and *O. kurisi* Shields, 1985. Palm (1995) considered *O. kurisi* to be a synonym of *O. penetrans*. *Otobothrium penetrans* has a basal swelling and distinctive basal armature as does *O. urii*. However, while the metabasal armature of *O. penetrans* consists of principal rows of seven hooks with two intercalary hooks between each row (Palm 1945; Palm *et al.* 1993), there are six hooks in the principal row in *O. urii* followed by a file of hooks (7/7) separated from the previous file by a distinct space (Fig. 16). In the centre of the anterobothridial surface of the tentacle is a band of hooklets, four files wide. The metabasal armature of *O. urii* differs therefore from every species of *Otobothrium* in which this feature has been adequately described (i.e.

penetrans, *O. pephrikos*, *O. insigne*, *O. vibratum* Subhapradha, 1955) but resembles that of the genera *Pseudobothrium* and *Poecilancistrum*, both of which have bands of hooklets on the external surface of the tentacle (Palm 1995; Beveridge & Campbell 1996). *Otobothrium urii* differs from *P. dipsacum* in possessing a distinctive basal swelling and armature, as well as lacking an increase in the number of hooks per principal row along the tentacle and having the rows of hooks beginning on the bothridial surface of the tentacle rather than the anterobothridial surface as in *P. dipsacum*. It differs from *Poecilancistrum* in having only one row of hooklets per principal row compared with three in *Poecilancistrum* (Beveridge & Campbell 1996).

Otobothrium urii also resembles *Poecilocanthum oweni*, described by Palm (1995) from an unidentified catfish from Papua New Guinea. The scolex of *P. oweni* appears to differ in having an extremely thick tegument, being much broader in the pars vaginalis (0.75 mm in *P. oweni*, 0.17 mm in *O. urii*) and having longer bulbs (1.1 mm in *P. oweni*, 0.57 mm in *O. urii*). The basal armature of the two species is remarkably similar. They differ however, in that while *P. oweni* has a chainette composed of triangular hooks on the external surface of its tentacle, *O. urii* has a band of hooklets.

While it may be possible to advance arguments for the erection of a new genus to accommodate *O. urii*, the existence of two monotypic genera within the Otobothriidae, *Pseudobothrium* and *Poecilancistrum*, as well as uncertainties concerning relationships with the monotypic genus *Poecilocanthum*, leads us to adopt a conservative approach in allocating *O. urii* to the genus *Pseudobothrium*. The definition of the genus must now include species with and without a basal armature and with the hook rows originating on either the bothridial or anterobothridial surfaces of the tentacle. The key feature which distinguishes *Pseudobothrium* from *Otobothrium* remains the character identified by Dollfus (1942), namely that the number of rows of hooks on the external surface of the tentacle is the same as in the internal surface in *Pseudobothrium* whereas there are more rows on the external surface in *Otobothrium*. *Pseudobothrium* and *Poecilancistrum* both differ from *Otobothrium* in possessing a band of hooklets on the tentacle rather than a single row of hooks interpolated between the intercalary rows. *Pseudobothrium* differs from *Poecilancistrum* in possessing one row of band hooks per principal row compared with three rows of band hooks in *Poecilancistrum*. All three genera differ from *Poecilocanthum* which possesses a chainette in the metabasal region. Details of the strobila as well as the addition of new species to these genera may facilitate the clarification of their relationships which

remain obscure at the present time.

The genus *Pseudobothrium*, as described here, includes two distinctive species of cestodes, intermediate between *Otobothrium* and *Poecilancistrum*. It may ultimately need to be dismembered, but indicates a hitherto unsuspected degree of diversity within the Otobothriidae, suggesting that additional novel species await discovery. A revised generic diagnosis is given below.

Pseudobothrium Dollfus, 1942

Definition

Otobothriidae Dollfus, 1942. Scolex, craspedote. Two bothridia with pair of fossettes on posterior margin. Pars vaginalis elongate. Bulbs elongate; retractor muscle originating from anterior part of bulb; prebulbar organ absent. Pars postbulbosa absent. Armature heteroacanthous, heteromorphous; hooks hollow. Distinctive basal armature present or absent. Hook rows begin on bothridial or

antibothridial surfaces of tentacles, terminate on opposite surface of tentacle; space present between principal rows and band of hooklets on bothridial or antibothridial surface of tentacle; band regularly arranged, with same number of rows as principal rows.

Type species: *P. dipsacum* (Linton, 1897).

Other species: *P. arii* (Bilqees & Shaukat, 1976) comb. nov.

Acknowledgments

The authors wish to thank L. R. G. Cannon, D. I. Gibson and R. J. Lichtenfels for access to specimens held in their collections, B. G. Robertson, P. Speare, S. C. Barker, R. A. Bray, T. H. Cribb, R. J. G. Lester and H. W. Palm for collecting specimens examined during this study, and M. Gomon, The Museum of Victoria, for advice on fish nomenclature. Financial support was provided by the Australian Biological Resources Study and the Australian Research Council.

References

- ALLEN, G. R. (1997) "Marine fishes of Tropical Australia and South East Asia." (Western Australian Museum, Perth).
- BATTS, R. M. (1990) A checklist of the Trypanorhynchidae (Platyhelminthes: Cestoda) of the world (1935-1985). *Nat. Mus. Wales Zool. Ser. No. 1*, 1-218.
- BILQUEES, I. & SHAUKAT, N. (1996) New records and redescriptions of trypanorhynch cestodes from Australian fishes. *Rev. S. Aust. Mus.* **29**, 1-22.
- & PALM, H. W. (1999) Preliminary cladistic analysis of genera of the cestode order Trypanorhyncha Diesing, 1863. *Syst. Parasitol.* **42**, 29-49.
- & JONES, M. R. (2000) *Prachistomella spinifera* n. sp. (Cestoda : Trypanorhyncha) from Australian dasycladid and rhinobatid rays. *Ibid.* **47**:1-8.
- BILQUEES, I. M. & SHAUKAT, N. (1976) *Otobothrium arii* sp. n. in the fish *Arius serratus* (Day) from Karachi coast, Agrio, Pakistan. **27**, 119-124.
- CAMPBELL, R. A. & BILQUEES, I. (1994) Order Trypanorhyncha Diesing, 1863 pp. 51-148. In Khalif, L., E. Jones, A. & Bray, R. A. (Eds) "Keys to the Cestodes of Vertebrates" (CAB International, Wallingford).
- CREZ-REYES, A. (1973) Cestodos de peces de Mexico. II. Redescripción del subgénero *Otobothrium* (*Pseudobothrium*) Dollfus, 1942 y de la especie *Otobothrium* (*P.*) *dipsacum* Linton, 1897. *Anal. Inst. Biol. Univ. Nac. Autón. México, ser. Zool.* **44**, 25-34.
- DOLLFUS, R.-P. (1942) Études critiques sur les tétraphyques du Muséum de Paris. *Arch. Mus. natl. Hist. nat., Paris*, 6^e sér. **19**, 1-466.
- HILDRETH, M. B. & LUMSER, R. D. (1985) Description of *Otobothrium insignis* plerocercus (Cestoda: Trypanorhyncha) and its incidence in catfish from the Gulf of Louisiana. *Proc. Helmholz. Soc. Wash.* **52**, 44-50.
- HISCOOK, I. D. (1954) A new species of *Otobothrium* (Cestoda: Trypanorhyncha) from Australian fishes. *Parasitology* **44**, 65-70.
- JOYNAUD, C. & BAER, J. G. (1936) Cestodes. *Faune de France* **30**, 1-613.
- LINTON, E. (1897) Notes on larval cestode parasites of fishes. *Proc. U. S. Nat. Mus.* **19**, 787-824.
- (1901) Parasites of fishes of the Wood's Hole region. *Bull. U. S. Comm. Fish Fisher.* **1899**, 405-492.
- (1905) Parasites of fishes of Beaufort, North Carolina. *Bull. Bur. Fish.* **1904**, 321-428.
- (1913) Cestoda pp. 585-589. In Sumner, F. B., Osburn, R. C. & Cole, L. J. (Eds) "A Catalogue of the Marine Fauna of Woods Hole and Vicinity, Part II" (Bulletin of the Bureau of Fisheries, Washington).
- (1924) Notes on cestode parasites of sharks and skates. *Proc. U. S. Nat. Mus.* **64**, 1-111.
- PALM, H. (1995) Untersuchungen zur Systematik von Rüsselbandwürmern (Cestoda : Trypanorhyncha) aus atlantischen Fischen. *Ber. Inst. Marées, Kiel* **275**, 1-238.
- (1997a) An alternative classification of trypanorhynch cestodes considering the tentacular armature as being of limited importance. *Syst. Parasitol.* **37**, 81-92.
- (1997b) Trypanorhynch cestodes of commercial fishes from northeast Brazilian coastal waters. *Mem. Inst. Oswaldo Cruz* **91**, 69-79.
- , MÖLLER, H. & PETERSEN, F. (1993) *Otobothrium peneriense* (Cestoda : Trypanorhyncha) in the flesh of belonid fish from Philippine waters. *Int. J. Parasitol.* **23**, 749-755.
- , OBIKEZE, A. & MÖLLER, H. (1994) Trypanorhynchid fishes of commercial inshore fishes of the West African coast. *Aquat. Liv. Res.* **7**, 153-164.
- PANTOM, J. R., HOEST, D. E., ALLEN, G. R. & HANLEY, J. (1989) Pisces. *Petromyzontidae* in *Crangidae*. "Zoological Catalogue of Australia", Vol. 7 (Australian Government Publishing Service, Canberra).
- PINTNER, T. (1934) Bruchstücke zur Kenntnis der Rüsselbandwürmer. *Zool. Jahrb. Anat.* **58**, 1-20.

- ROBINS, C. R., BAILEY, R. M., BOND, C. E., BROOKER, J. R., LACHNER, E. A., LEA, R. N. & SCOTT, W. B. (1991) "Common and scientific names of fishes from the United States and Canada. Fifth edn" (American Fisheries Society Special Publication 20, Maryland).
- SCHMIDT, G. D. (1986) "Handbook of Tapeworm Identification" (CRC Press, Boca Raton, Florida).
- SOUTHWELL, T. (1912) A description of ten new species of cestode parasites from marine fishes of Ceylon, with notes on other cestodes from the same region. *Ceylon Mar. Biol. Rep.*, Part VI, No. 22, 259-277.
- _____. (1913) On some Indian Cestoda. *Rec. Ind. Mus.* **9**, 279-300.
- _____. (1924) Notes on some tetrarhynchid parasites from Ceylon marine fishes. *Ann. Trop. Med. Parasitol.* **18**, 459-491.
- _____. (1929) A monograph on cestodes of the order Trypanorhyncha from Ceylon and India. Part I. *Spol. Zeyland.* **15**, 169-312.
- _____. (1930) Cestoda. "The Fauna of British India including Ceylon and Burma" Vol. I (Taylor & Francis, London).
- WARD, H. L. (1954) Parasites of marine fishes of the Miami region. *Bull. Mar. Sci. Gulf Caribb.* **4**, 244-261.
- YAMAGUTI, S. (1952) Studies on the helminth fauna of Japan. Part 49. Cestodes of Fishes. *Acta Med. Okayama* **8**, 1-78.
- _____. (1959) "Systema Helminthum, The Cestodes of Vertebrates, Vol. 2" (Wiley Interscience, New York).